FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
112740-344	10/009858

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/01021	03 April 2000	22 April 1999

TITLE OF INVENTION

METHOD FOR CONTROLLING TRANSMISSION POWER IN A RADIO SYSTEM, AND A CORRESPONDING RADIO SYSTEM

APPLICANT(S) FOR DO/EO/US

Bernhard Raaf

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☒ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☒ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☒ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☒ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Submission of Drawings Figures 1-3 on two sheets

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/009858	PCT/DE00/01021	112740-344

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS PTO USE ONLY
☐	Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**	
☒	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**	
☐	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**	
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**	
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**	
	ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**
	Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	24 - 20 =	4	x $18.00	**$72.00**
Independent claims	2 - 3 =	0	x $84.00	**$0.00**
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**

TOTAL OF ABOVE CALCULATIONS =	**$962.00**
☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.	**$0.00**
SUBTOTAL =	**$962.00**
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +	**$0.00**
TOTAL NATIONAL FEE =	**$962.00**
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐	**$0.00**
TOTAL FEES ENCLOSED =	**$962.00**
Amount to be: refunded	$
charged	$

a. ☒ A check in the amount of **$962.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **02-1818** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

William E. Vaughan (Reg. No. 39,056)
Bell, Boyd & Lloyd LLC
P.O. Box 1135
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SIGNATURE

William E. Vaughan
NAME

39,056
REGISTRATION NUMBER

October 22, 2001
DATE

BOX PCT

IN THE UNITED STATES ELECTED/DESIGNATED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

PRELIMINARY AMENDMENT

APPLICANT:	Bernhard Raaf	DOCKET NO: 112740-344
SERIAL NO:		GROUP ART UNIT:
		EXAMINER:
INTERNATIONAL APPLICATION NO:		PCT/DE00/01021
INTERNATIONAL FILING DATE:		03 April 2000
INVENTION:	METHOD FOR CONTROLLING TRANSMISSION POWER IN A RADIO SYSTEM, AND A CORRESPONDING RADIO SYSTEM	

Assistant Commissioner for Patents,
Washington, D.C. 20231

Sir:

Please amend the above-identified International Application before entry into the National stage before the U.S. Patent and Trademark Office under 35 U.S.C. §371 as follows:

In the Specification:

Please replace the Specification of the present application, including the Abstract, with the following Substitute Specification:

SPECIFICATION

TITLE OF THE INVENTION

METHOD FOR CONTROLLING TRANSMISSION POWER IN A RADIO SYSTEM, AND A CORRESPONDING RADIO SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a method for controlling the transmission power in a radio system, and to a corresponding radio system, in particular a corresponding mobile radio system.

Transmission power control in mobile radio systems is an important performance feature in order to be able to suppress possible interference between

the individual connections and, hence, to allow the capacity and quality of the connections to be improved, as well as to be able to reduce the mean transmission power, to achieve the best possible matching to the requirements and to allow losses via the transmission channels to be at least partially compensated for.

To this end, the signal transmitted by a transmitter is evaluated at the receiving end in the mobile radio system in order to allow information to be produced as a function of this for power control, and to allow this information to be transmitted to the transmitter, which then adjusts the transmission power in accordance with the power control information.

In order to explain the principle of power control in more detail, Figure 2 shows the communication between a base station 1 and a mobile station 2 in a mobile radio system. A connection from the base station 1 to the mobile part 2 is referred to as the downlink or forward link connection, while a connection from the mobile part 2 to the base station 1 is referred to as the uplink connection, or reverse link connection. For power control in the downlink, the respective received signal is evaluated in the mobile station 2, and power control information is produced as a function of this and sent back to the base station 1, so that the base station 1 can adjust the transmission power appropriately. In order to control the uplink, the received signal is evaluated in the base station 1, where the power control information is produced and the mobile station 2 is instructed to carry out power matching.

The power control information is, in this case, transmitted within a predetermined frame structure, depending on the respective mobile radio system.

Figure 3 shows an example of the frame and timeslot structure for a downlink connection in a mobile radio system operated using a code division multiple access method (CDMA). The frame and timeslot structure shown in Figure 3 corresponds, in particular, to a UMTS mobile radio channel (Universal Mobile Telecommunications System), which is also referred to as DPCH (Dedicated Physical Channel) in accordance with the current state of UMTS standardization. UMTS is the designation for third-generation mobile radio systems, with the aim of a worldwide, universal mobile radio standard. According to the UMTS mobile

radio standard, the WCDMA method (Wideband Code Division Multiple Access) is intended for use as the multiple access method.

The frame structure shown in Figure 3 and with a duration of 720 ms includes, in particular, 72 frames 3 of identical construction and having a frame duration of 10 ms, with each frame, in turn, having 16 timeslots 4, with a timeslot duration of 0.625 ms. Each timeslot 4 includes information split between a logical control channel (DPCCH, Dedicated Physical Control Channel) and a logical data channel (DPDCH, Dedicated Physical Data Channel). The DPCCH section includes a pilot bit sequence 5 and TPC information (Transmitter Power Control) 6 and TFI information (Transmitter Format Identifier) 7. The DPDCH section includes user data bits 8. The structure shown in Figure 3 can be found, for example, in the document ETSI STC SMG2 UMTS-L1: Tdoc SMG2 UMTS-L1 221/98.

The pilot bit sequence 5 is used for estimating the channel impulse response during a training sequence, and corresponds to a known bit pattern. The receiver can determine or estimate the channel impulse response of the mobile radio channel by comparing the received signal with the known pilot bit sequence.

The TFI information 7 is used for format identification for the respective receiver. The TFI bits are protected, according to the present WCDMA Standard, via a specific coding method, and are distributed over an entire frame (time duration 10 ms) by interleaving. If the TFI information 7 in each timeslot includes, for example, three bits b4...b5 as shown in Figure 3, there are a total of $3*16 = 48$ TFI bits per frame, which includes 16 timeslots, and these bits are coded via a bi-orthogonal coding method.

The TPC information 6 represents the command, produced by the receiver and transmitted to the transmitter, to adjust the transmission power. To do this, the received power in the receiver or the signal-to-noise ratio in the received signal is compared with a predetermined reference value, and the value for the power adjustment command is determined as a function of the discrepancy. As such, if the received power exceeds the reference value, a command is produced to reduce the transmission power, while a command to increase the transmission power is produced if the received power is less than the predetermined reference value.

Thus, depending on the comparison result, the receiver transmits a digital or binary adjustment command to the transmitter. In this case, a command to increase the transmission power (power up command) is coded with a 1, while a command to reduce the transmission power (power down command) is coded with a 0. In each case, the adjustment command is transmitted to the transmitter after appropriate modulation. According to the WCDMA Standard for UMTS mobile radio systems that is currently under discussion, the transmission is carried out via QPSK modulation (Quadrature Phase Shift Keying), by which the binary 1 or 0 are changed to respective values -1 and +1, followed by the power control signal being spread.

The power control information, thus, generally includes only one bit, which indicates whether the transmission power should be increased or reduced at the transmission end. In order to allow this bit to be transmitted with a sufficiently low error probability, the bit is transmitted repeatedly. The TPC information shown in Figure 3 in consequence, for example, includes three bits b1...b3, which are transmitted successively with identical information contents. However, the power control information also may include a different number of bits; for example, more bits.

Relatively powerful coding methods which are known per se and via which it would be possible to achieve a better error probability are not used since the TPC bits will need to be evaluated immediately in the receiver of the TPC information, in order to allow the transmission power to be readjusted appropriately without delay. According to the prior art, the TPC bits are not coded together with other bits or data and also can not be distributed over a relatively long time period, for example over an entire frame, which is referred to as interleaving.

However, there is a requirement for the TPC bits to be transmitted correctly with as high a reliability level as possible in order to avoid the transmitter incorrectly or not reliably receiving the corresponding power adjustment command.

The document ETSI SMG2 L1 Expert Group, Tdos SMG2 UMTS-L1 736/98, Espoo, Finland, December 14-18, 1998, "Soft TPC Interpretation for Improved Closed Loop Power Control" discusses the reliability of the power

adjustment command transmitted to the transmitter, and adjustment in as optimum a manner as possible of the value of the power adjustment command as a function of the reliability of its reception. In this case, the authors indicate that the value of the power adjustment command should be chosen depending on the function tanh ($\Lambda/2$), where Λ represents the reliability of the power adjustment command in the form of a log-likelihood distribution.

The present invention is directed toward providing an improved method for controlling the transmission power in a radio system, in particular in a mobile radio system, as well as a corresponding radio system, by which the reliability of transmission of the power control information can be improved.

SUMMARY OF THE INVENTION

According to the present invention, the power control information transmitted in one timeslot is coded together with further data which is intended to be transmitted in the same timeslot. Both the power control information and this further data or information are preferably transmitted in binary form, so that the power control information (TPC bits) transmitted in one timeslot is not simply transmitted repeatedly, but is coded together with further bits, which are intended to be transmitted within the same timeslot. These further bits may be, for example, the bits in the TFI information (TFI bits) in a WCDMA mobile radio system. However, in principle, other bits, for example data bits, also can be used for coding with the TPC bits, provided they are intended to be, or can be, transmitted in the same timeslot at the TPC bits.

The coding method used for coding the TPC bits can in principle, be chosen as required. However, the coding method is advantageously chosen such that the coding process provides added redundancy, which can be utilized during reception of the coded power control information to check the transmitted value of the power control information.

The coding method may, for example, include the TPC bits being coded together with the further bits to be coded with them to form a common binary data word, at least some of whose bit values depend not only on the value of the TPC bits but also on the value of the further bits, for example the TFI bits. The bits to be

coded with one another can, thus, in particular, be linked via a logic exclusive-OR operation.

An advantage of the present invention is that the added redundancy, which results from the dependency of the coded bits on both the value of the TPC bits and the value of the further bits to be coded with them, allows additional estimated values to be obtained for the power control information to be transmitted, which then can be used to check the received power control information, in order to increase the reliability of transmission of the power control information.

The present invention is preferably used in CDMA mobile radio systems, especially in WCDMA mobile radio systems, such as the UMTS mobile radio system. Furthermore, the present invention is preferably used in a mobile radio system in the downlink, that is to say for transmission of the power control information from the base station to the mobile station, since CDMA mobile radio systems have increased delay times in the uplink, owing to the code division multiplexing method used. In principle, the present invention can, however, be applied to any type of radio system in which it is intended to transmit power control information embedded in a (frame and) timeslot structure.

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the frame and timeslot structure according to the present invention for a downlink connection in a WCDMA mobile radio system to which the present invention is preferably applied.

Figure 2 shows a schematic illustration of a mobile radio system in order to explain the information transmission for power control.

Figure 3 shows the known frame and timeslot structure for a downlink connection in a WCDMA mobile radio system.

DETAILED DESCRIPTION OF THE INVENTION

The frame and timeslot structure shown in Figure 1 indicates the principle on which the present invention is based, with the fundamental layout of this

structure corresponding to the structure shown in Figure 3, so that reference also should be made to the corresponding explanatory notes relating to Figure 3.

As has already been described initially, in the structure shown in Figure 3, the bits for power control information 6 (referred to as TPC bits in the following text) are transmitted separately from the further information, to be transmitted in the same timeslot, in a timeslot 4. In particular, the power control information normally includes only one bit value, which is transmitted a number of times successively, according to Figure 3, for example, three times in the form of the TPC bits b1...b3. The further control and data bits are separated from the TPC bits b1...b3.

However, according to the present invention, this separation is canceled, and the TPC bits b1...b3 are coded together with further bits which are transmitted in the same timeslot 4. These may be, for example, the bits in the format identification information 7 (referred to as TFI bits in the following text). However, other bits, such as bits in the data information 8, also can be used for coding the TPC bits.

In order to explain the principle on which the present invention is based, it is assumed by way of example in the following text that the power control information includes three TPC bits b1...b3, which are intended to be coded, in redundant form, together with three TFI bits b4...b6 of format identification information. The value of the power control information to be transmitted is denoted p, while the value of the format identification information to be transmitted in the same timeslot 4 is denoted t.

With the conventional structure shown in Figure 3, the bits b1...b3 would all be assigned the value p, while the bits b4...b6 would define the value t, separately from this.

According to one preferred exemplary embodiment of the present invention, it is now proposed that a coded data word which is common to the power control information and format identification information be generated from the bits b1...b6, at least some of whose bit values are influenced not only by the value p but

also by the value t. In particular, the bits b1...b6 in this coded data word can be allocated as follows, in the course of coding:

b1 = b2 = p
b3 = b4 = p XOR t
b5 = b6 = t

The coded data word thus includes a total number of bits corresponding to the sum of the TPC bits and TFI bits, in which, however, some of the bits in this data word are occupied only with the TPC value p (see the bits b1 and b2), while a further portion of this data word is occupied only by the TFI value t (see the bits b5 and b6). A third section of the data word is, finally, obtained via a logic operation, in particular via a logic exclusive-OR operation, between the TPC value p and the TFI value t (see the bits b3 and b4). Thus, in comparison to the conventional structure shown in Figure 3, the bits b3...b6 are used differently in the coding method described above.

After the transmission of this code word with the coded bits b1...b6 to the transmitter for appropriate readjustment of the transmission power, the transmitter can use the information contained in the bits b3...b6 to calculate an estimated value p' for the TPC information. To do this, the transmitter uses b5 and b6 to determine an estimated value for t, so that the estimated value p' can be calculated from the bits b3 and b4, on the basis of the estimated value of t, and utilizing the known XOR function.

This estimated value p' thus replaces the estimated value for the power control information obtained from the bit b3 when using the known structure shown in Figure 3. This procedure has the advantage that p' is, in each case, based on two bits, with this combination making it possible to achieve a transmission capability that is improved by 3 dB.

The calculation of the XOR function admittedly results in a higher bit error rate. However, at least when the channel or transmission conditions are not very bad, this is more than compensated for by the gain. This will be explained briefly below.

If f denotes the probability that a bit will be detected incorrectly, then the probability of incorrect detection is improved approximately to f^2 if this bit is

transmitted twice. On the other hand, the probability of incorrect detection resulting from the XOR calculation deteriorates approximately to 2f since, in this case, the XOR calculation produces an incorrect value just by one of the two XOR-linked values or bits having been detected incorrectly. The coding method described above thus gives better results provided the following relationship is satisfied:

$2f^2 < f$

or

$f < 0.5$

This relationship is satisfied for WCDM transmission methods, so that the present invention ensures improved transmission reliability, particularly when used in (W)CDMA mobile radio systems.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

ABSTRACT OF THE DISCLOSURE

In a radio system, in particular a CDMA mobile radio system, a receiver evaluates a signal received from a transmitter and produces power control information for setting the transmission power as a function of this evaluation. In order to improve the transmission reliability of the power control information, it is coded, and is transmitted to the transmitter, together with further data from the said timeslot, for example with bits from the format identification information.

In the claims:

On page 11, cancel line 1 and substitute the following left-hand justified heading therefor:

CLAIMS

Please cancel claims 1-24, without prejudice, and substitute the following claims therefor:

25. A method for controlling transmission power in a radio system, the method comprising the steps of:

evaluating a signal received by a receiver via a transmission channel of the radio system from a transmitter;

producing power control information as a function of the evaluation;

sending the power control information, embedded in a time slot structure, to the transmitter;

setting the transmission power in the transmitter as a function of the power control information;

coding, in the receiver, the power control information in one time slot, with the addition of redundancy, together with further data to be transmitted in the same one time slot to form a common data word, with at least one bit value in the data word depending on the power control information and on the further data; and

transmitting the power control information to the transmitter, together with the further data to be transmitted, in the one time slot.

26. A method for controlling transmission power in a radio system as claimed in claim 25, wherein the further data is data for format identification information.

27. A method for controlling transmission power in a radio system as claimed in claim 25, wherein the further data is user data.

28. A method for controlling transmission power in a radio system as claimed in claim 25, wherein the power control information is transmitted in binary form.

29. A method for controlling transmission power in a radio system as claimed in claim 28, wherein bits in the power control information are coded with bits of the further data to form a common binary data word.

30. A method for controlling transmission power in a radio system as claimed in claim 29, wherein the coded data word includes a plurality of bits

corresponding to a sum of the bits in the power control information and the bits in the further data.

31. A method for controlling transmission power in a radio system as claimed in claim 29, wherein, during the coding process, at least one bit in the coded data word is assigned a value of the power control information to be transmitted in the corresponding one time slot.

32. A method for controlling transmission power in a radio system as claimed in claim 29, wherein, during the coding process, at least one bit in the coded data word is assigned a value of the information to be transmitted in the corresponding one time slot from the further data.

33. A method for controlling transmission power in a radio system as claimed in claim 29, wherein, during the coding process, at least one bit in the coded data word is assigned a value which corresponds to a logic operation between the power control information to be transmitted in the corresponding one time slot and the information to be transmitted in the same one time slot from the further data.

34. A method for controlling transmission power in a radio system as claimed in claim 33, wherein a logic exclusive-OR operation is used as the logic operation.

35. A method for controlling transmission power in a radio system as claimed in claim 33, wherein the power control information is recovered in the transmitter via appropriate decoding, with an estimated value being determined for the power control information during the decoding process based on a value obtained by the logic operation from the corresponding bit in the coded data word.

36. A method for controlling transmission power in a radio system as claimed in claim 25, wherein the receiver which produces the coded power control information is a base station in a mobile radio system, and the transmitter which receives the power control information and sets its transmission level appropriately is a mobile station in the mobile radio system, such that the coded power control information is transmitted via a downlink connection between the receiver and the transmitter.

37. A radio system, comprising:

a transmitter; and

a receiver for receiving a signal, which is transmitted via a transmission channel of the mobile radio system, from the transmitter and for evaluating the received signal, so as to produce power control information which is dependent on the received signal and to send the power control information, embedded in a time slot structure, to the transmitter;

wherein the transmitter sets the transmission power as a function of the power control information from the receiver, the receiver codes the power control information for one time slot, with the addition of redundancy, together with further data to be transmitted in the same one time slot to form a common data word, with at least one bit value in the data word depending on the power control information and on the further data, and transmits the power control information to the transmitter, together with further data to be transmitted in the same one time slot.

38. A radio system as claimed in claim 37, wherein the receiver codes the power control information together with data from format identification information for the same one time slot.

39. A radio system as claimed in claim 38, wherein the receiver codes the power control information together with user data for the same one time slot.

40. A radio system as claimed in claim 37, wherein the receiver sends the power control information to the transmitter in binary form.

41. A radio system as claimed in claim 40, wherein the receiver codes the bits in the power control information together with bits in the further data to form a common binary data word.

42. A radio system as claimed in claim 41, wherein the receiver, during the coding process, assigns at least one bit in the coded common data word a value of the power control information to be transmitted in the corresponding one time slot.

43. A radio system as claimed in claim 41, wherein the receiver, during the coding process, assigns at least one bit in the coded common data word a value of the information to be transmitted in the corresponding one time slot from the further data.

44. A radio system as claimed in claim 41, wherein the receiver, during the coding process, assigns at least one bit in the coded common data word a value which corresponds to a logic operation between the power control information to be transmitted in the corresponding one time slot and the information to be transmitted in the same one time slot from the further data.

45. A radio system as claimed in claim 44, wherein the logic operation carried out by the receiver during the coding process is a logic exclusive-OR operation.

46. A radio system as claimed in claim 44, wherein the transmitter, after receiving the coded common data word, recovers the power control information via appropriate decoding and determines an estimated value for the power control

information based on the value obtained by the logic operation from the corresponding bit in the coded common data word.

47. A radio system as claimed in claim 37, wherein the radio system is a CDMA mobile radio system.

48. A radio system as claimed in claim 47, wherein the receiver which produces the coded binary power control information is a base station in the mobile radio system, and the transmitter which receives the power control information and sets its transmission power appropriately is a mobile station in the mobile radio system.

REMARKS

The present amendment makes editorial changes and corrects typographical errors in the specification, which includes the Abstract, in order to conform the specification to the requirements of United States Patent Practice. No new matter is added thereby. Attached hereto is a marked-up version of the changes made to the specification by the present amendment. The attached page is captioned "**Version With Markings To Show Changes Made**".

In addition, the present amendment cancels original claims 1-24 in favor of new claims 25-48. Claims 25-48 have been presented solely because the revisions by crossing out underlining which would have been necessary in claims 1-24 in order to present those claims in accordance with preferred United States Patent Practice would have been too extensive, and thus would have been too burdensome. The present amendment is intended for clarification purposes only and not for substantial reasons related to patentability pursuant to 35 U.S.C. §§103, 102, 103 or 112. Indeed, the cancellation of claims 1-24 does not constitute an intent on the part of the Applicants to surrender any of the subject matter of claims 1-24.

Early consideration on the merits is respectfully requested.

Respectfully submitted,

_________________________ (Reg. No. 39,056)

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VERSIONS WITH MARKINGS TO SHOW CHANGES MADE

In The Specification:

The Specification of the present application, including the Abstract, has been amended as follows:

SPECIFICATION

TITLE OF THE INVENTION

~~Description~~

~~Method for controlling the transmission power in a radio system, and a corresponding radio system~~

METHOD FOR CONTROLLING TRANSMISSION POWER IN A RADIO SYSTEM, AND A CORRESPONDING RADIO SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a method for controlling the transmission power in a radio system, and to a corresponding radio system, in particular a corresponding mobile radio system.

Transmission power control in mobile radio systems is an important performance feature in order to be able to suppress possible interference between the individual connections and, hence, to allow the capacity and quality of the connections to be improved, as well as to be able to reduce the mean transmission power, to achieve the best possible matching to the requirements and to allow losses via the transmission channels to be at least partially compensated for.

To this end, the signal transmitted by a transmitter is evaluated at the receiving end in the mobile radio system in order to allow information to be produced as a function of this for power control, and to allow this information to be transmitted to the transmitter, which then adjusts the transmission power in accordance with the power control information.

In order to explain the principle of power control in more detail, Figure 2 shows the communication between a base station 1 and a mobile station 2 in a mobile radio system. A connection from the base station 1 to the mobile part 2 is referred to as the downlink or forward link connection, while a connection from the mobile part 2 to the base station 1 is referred to as the uplink connection, or reverse

link connection. For power control in the downlink, the respective received signal is evaluated in the mobile station 2, and power control information is produced as a function of this and ~~is~~ sent back to the base station 1, so that the base station 1 can adjust the transmission power appropriately. In order to control the uplink, the received signal is evaluated in the base station 1, where the power control information is produced and the mobile station 2 is instructed to carry out power matching.

The power control information is, in this case, transmitted within a predetermined frame structure, depending on the respective mobile radio system.

Figure 3 shows an example of the frame and timeslot structure for a downlink connection in a mobile radio system operated using a code division multiple access method (CDMA). The frame and timeslot structure shown in Figure 3 corresponds, in particular, to a UMTS mobile radio channel (Universal Mobile Telecommunications System), which is also referred to as DPCH (Dedicated Physical Channel) in accordance with the current state of UMTS standardization. UMTS is the designation for third-generation mobile radio systems, with the aim of a worldwide, universal mobile radio standard. According to the UMTS mobile radio standard, the WCDMA method (Wideband Code Division Multiple Access) is intended for use as the multiple access method.

The frame structure shown in Figure 3 and with a duration of 720 ms ~~comprises~~ includes, in particular, 72 frames 3 of identical construction and having a frame duration of 10 ms, with each frame, in turn, ~~each~~ having 16 timeslots 4, with a timeslot duration of 0.625 ms. Each timeslot 4 ~~comprises~~ includes information split between a logical control channel (DPCCH, Dedicated Physical Control Channel) and a logical data channel (DPDCH, Dedicated Physical Data Channel). The DPCCH section ~~comprises~~ includes a pilot bit sequence 5 and TPC information (Transmitter Power Control) 6 and TFI information (Transmitter Format Identifier) 7. The DPDCH section ~~comprises~~ includes user data bits 8. The structure shown in Figure 3 can be found, for example, in the document ETSI STC SMG2 UMTS-L1: Tdoc SMG2 UMTS-L1 221/98.

The pilot bit sequence 5 is used for estimating the channel impulse response during a training sequence, and corresponds to a known bit pattern. The receiver can determine or estimate the channel impulse response of the mobile radio channel by comparing the received signal with the known pilot bit sequence.

The TFI information 7 is used for format identification for the respective receiver. The TFI bits are protected, according to the present WCDMA Standard, ~~by means of~~ via a specific coding method, and are distributed over an entire frame (time duration 10 ms) by interleaving. If the TFI information 7 in each timeslot ~~comprises~~ includes, for example, three bits b4...b5 as shown in Figure 3, there are a total of 3*16 = 48 TFI bits per frame, which ~~comprises~~ includes 16 timeslots, and these bits are coded ~~by means of~~ via a bi-orthogonal coding method.

The TPC information 6 represents the command, produced by the receiver and transmitted to the transmitter, to adjust the transmission power. To do this, the received power in the receiver or the signal-to-noise ratio in the received signal is compared with a predetermined reference value, and the value for the power adjustment command is determined as a function of the discrepancy. ~~This means that~~ As such, if the received power exceeds the reference value, a command is produced to reduce the transmission power, while a command to increase the transmission power is produced if the received power is less than the predetermined reference value. Thus, depending on the comparison result, the receiver transmits a digital or binary adjustment command to the transmitter. In this case, a command to increase the transmission power (power up command) is coded with a 1, while a command to reduce the transmission power (power down command) is coded with a 0. In each case, the adjustment command is transmitted to the transmitter after appropriate modulation. According to the WCDMA Standard for UMTS mobile radio systems that is currently under discussion, the transmission is carried out ~~by means of~~ via QPSK modulation (Quadrature Phase Shift Keying), by which ~~means~~ the binary 1 or 0 are changed to respective values -1 and +1, followed by the power control signal being spread.

The power control information, thus, generally ~~comprises~~ includes only one bit, which indicates whether the transmission power should be increased or reduced

at the transmission end. In order to allow this bit to be transmitted with a sufficiently low error probability, the bit is transmitted repeatedly. The TPC information shown in Figure 3 in consequence, for example, ~~comprises~~ includes three bits b1...b3, which are transmitted successively with identical information contents. However, the power control information ~~may~~ also ~~comprise~~ may include a different number of bits~~,~~; for example, more bits.

Relatively powerful coding methods which are known per se and ~~by means of~~ via which it would be possible to achieve a better error probability are not used since the TPC bits will need to be evaluated immediately in the receiver of the TPC information~~,~~ in order to allow the transmission power to be readjusted appropriately without delay. According to the prior art, the TPC bits are ~~thus~~ not coded together with other bits or data and also can ~~also~~ not be distributed over a relatively long time period, for example over an entire frame, which is referred to as interleaving.

However, there is a requirement for the TPC bits to be transmitted correctly with as high a reliability level as possible in order to avoid the transmitter incorrectly or not reliably receiving the corresponding power adjustment command.

The document ETSI SMG2 L1 Expert Group, Tdos SMG2 UMTS-L1 736/98, Espoo, Finland, December 14-18, 1998, "Soft TPC Interpretation for Improved Closed Loop Power Control" discusses the reliability of the power adjustment command transmitted to the transmitter, and adjustment in as optimum a manner as possible of the value of the power adjustment command as a function of the reliability of its reception. In this case, the authors indicate that the value of the power adjustment command should be chosen depending on the function tanh ($\Lambda/2$), where Λ represents the reliability of the power adjustment command in the form of a log-likelihood distribution.

The present invention is ~~based on the object of~~ directed toward providing an improved method for controlling the transmission power in a radio system, in particular in a mobile radio system, as well as a corresponding radio system, by which ~~means~~ the reliability of transmission of the power control information can be improved.

~~According to the invention, this object is achieved by a method having the features of claim 1, and by a corresponding mobile radio system having the features of claim 13. The dependent claims each describe preferred and advantageous embodiments of the present invention.~~

SUMMARY OF THE INVENTION

According to the present invention, the power control information transmitted in one timeslot is coded together with further data which is intended to be transmitted in the same timeslot. Both the power control information and this further data or information are preferably transmitted in binary form, so that the power control information (TPC bits) transmitted in one timeslot is not simply transmitted repeatedly, but is coded together with further bits, which are intended to be transmitted within the same timeslot. These further bits may be, for example, the bits in the TFI information (TFI bits) in a WCDMA mobile radio system. However, in principle, other bits, for example data bits, ~~can~~ also can be used for coding with the TPC bits, provided they are intended to be, or can be, transmitted in the same timeslot at the TPC bits.

The coding method used for coding the TPC bits can in principle, be chosen as required. However, the coding method is advantageously chosen such that the coding process provides added redundancy, which can be utilized during reception of the coded power control information to check the transmitted value of the power control information.

The coding method may, for example, ~~comprise~~ include the TPC bits being coded together with the further bits to be coded with them to form a common binary data word, at least some of whose bit values depend not only on the value of the TPC bits but also on the value of the further bits, for example the TFI bits. The bits to be coded with one another can, thus, in particular, be linked ~~by means of~~ via a logic exclusive-OR operation.

~~The~~ An advantage of the present invention is that the added redundancy, which results from the dependency of the coded bits on both the value of the TPC bits and the value of the further bits to be coded with them, allows additional estimated values to be obtained for the power control information to be transmitted,

which then can ~~then~~ be used to check the received power control information, in order to increase the reliability of transmission of the power control information.

The present invention is preferably used in CDMA mobile radio systems, especially in WCDMA mobile radio systems, such as the UMTS mobile radio system. Furthermore, the present invention is preferably used in a mobile radio system in the downlink, that is to say for transmission of the power control information from the base station to the mobile station, since CDMA mobile radio systems have increased delay times in the uplink, owing to the code division multiplexing method used. In principle, the present invention can, however, be applied to any type of radio system in which it is intended to transmit power control information embedded in a (frame and) timeslot structure.

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

~~The invention will be explained in more detail in the following text with reference to the attached drawing on the basis of use in the downlink of a WCDMA mobile radio system, in particular a UMTS mobile radio system. In this case:~~

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the frame and timeslot structure according to the present invention for a downlink connection in a WCDMA mobile radio system to which the present invention is preferably applied~~;~~.

Figure 2 shows a schematic illustration of a mobile radio system in order to explain the information transmission for power control~~, and~~.

Figure 3 shows the known frame and timeslot structure for a downlink connection in a WCDMA mobile radio system.

DETAILED DESCRIPTION OF THE INVENTION

The frame and timeslot structure shown in Figure 1 indicates the principle on which the present invention is based, with the fundamental layout of this structure corresponding to the structure shown in Figure 3, so that reference also should ~~also~~ be made to the corresponding explanatory notes relating to Figure 3.

As has already been described initially, in the structure shown in Figure 3, the bits for power control information 6 (referred to as TPC bits in the following text) are transmitted separately from the further information, to be transmitted in the same timeslot, in a timeslot 4. In particular, the power control information normally ~~comprises~~ includes only one bit value, which is transmitted a number of times successively, according to Figure 3, for example, three times in the form of the TPC bits b1...b3. The further control and data bits are separated from the TPC bits b1...b3.

However, according to the present invention, this separation is canceled, and the TPC bits b1...b3 are coded together with further bits which are transmitted in the same timeslot 4. These may be, for example, the bits in the format identification information 7 (referred to as TFI bits in the following text). However, other bits, such as bits in the data information 8, ~~can~~ also can ~~possibly~~ be used for coding the TPC bits.

In order to explain the principle on which the present invention is based, it is assumed by way of example in the following text that the power control information ~~comprises~~ includes three TPC bits b1...b3, which are intended to be coded, in redundant form, together with three TFI bits b4...b6 of format identification information. The value of the power control information to be transmitted is denoted p, while the value of the format identification information to be transmitted in the same timeslot 4 is denoted t.

With the conventional structure shown in Figure 3, the bits b1...b3 would all be assigned the value p, while the bits b4...b6 would define the value t, separately from this.

According to one preferred exemplary embodiment of the present invention, it is now proposed that a coded data word which is common to the power control information and format identification information be generated from the bits b1...b6, at least some of whose bit values are influenced not only by the value p but also by the value t. In particular, the bits b1...b6 in this coded data word can be allocated as follows, in the course of coding:

b1 = b2 = p

b3 = b4 = p XOR t
b5 = b6 = t

The coded data word thus ~~comprises~~ includes a total number of bits corresponding to the sum of the TPC bits and TFI bits, in which, however, some of the bits in this data word are occupied only with the TPC value p (see the bits b1 and b2), while a further portion of this data word is occupied only by the TFI value t (see the bits b5 and b6). A third section of the data word is, finally, obtained ~~by means of~~ via a logic operation, in particular ~~by means of~~ via a logic exclusive-OR operation, between the TPC value p and the TFI value t (see the bits b3 and b4). Thus, in comparison to the conventional structure shown in Figure 3, the bits b3...b6 are used differently in the coding method described above.

After the transmission of this code word with the coded bits b1...b6 to the transmitter for appropriate readjustment of the transmission power, the transmitter can use the information contained in the bits b3...b6 to calculate an estimated value p' for the TPC information. To do this, the transmitter uses b5 and b6 to determine an estimated value for t, so that the estimated value p' can be calculated from the bits b3 and b4, on the basis of the estimated value of t, and utilizing the known XOR function.

This estimated value p' thus replaces the estimated value for the power control information obtained from the bit b3 when using the known structure shown in Figure 3. This procedure has the advantage that p' is, in each case, based on two bits, with this combination making it possible to achieve a transmission capability that is improved by 3 dB.

The calculation of the XOR function admittedly results in a higher bit error rate. However, at least when the channel or transmission conditions are not very bad, this is more than compensated for by the gain. This will be explained briefly below.

If f denotes the probability that a bit will be detected incorrectly, then the probability of incorrect detection is improved approximately to f^2 if this bit is transmitted twice. On the other hand, the probability of incorrect detection resulting

from the XOR calculation deteriorates approximately to 2f since, in this case, the XOR calculation produces an incorrect value just by one of the two XOR-linked values or bits having been detected incorrectly. The coding method described above thus gives better results provided the following relationship is satisfied:

$2f^2 < f$

or

$f < 0.5$

This relationship is satisfied for WCDM transmission methods, so that the present invention ensures improved transmission reliability, particularly when used in (W)CDMA mobile radio systems.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

~~Abstract~~

ABSTRACT OF THE DISCLOSURE

~~Method for controlling the transmission power in a radio system, and a corresponding radio system~~

In a radio system, in particular a CDMA mobile radio system, a receiver ~~(1; 2)~~ evaluates a signal received from a transmitter ~~(2; 1)~~ and produces power control information ~~(6)~~ for setting the transmission power as a function of this evaluation. In order to improve the transmission reliability of the power control information ~~(6)~~, it is coded, and is transmitted to the transmitter ~~(2; 1)~~, together with further data from the said timeslot, for example with bits from the format identification information ~~(7)~~.

~~(Figure 1)~~

2/prts

Description

Method for controlling the transmission power in a radio system, and a corresponding radio system

The present invention relates to a method for controlling the transmission power in a radio system, and to a corresponding radio system, in particular a corresponding mobile radio system.

Transmission power control in mobile radio systems is an important performance feature in order to be able to suppress possible interference between the individual connections and hence to allow the capacity and quality of the connections to be improved, as well as to be able to reduce the mean transmission power, to achieve the best possible matching to the requirements and to allow losses via the transmission channels to be at least partially compensated for.

To this end, the signal transmitted by a transmitter is evaluated at the receiving end in the mobile radio system in order to allow information to be produced as a function of this for power control, and to allow this information to be transmitted to the transmitter, which then adjusts the transmission power in accordance with the power control information.

In order to explain the principle of power control in more detail, Figure 2 shows the communication between a base station 1 and a mobile station 2 in a mobile radio system. A connection from the base station 1 to the mobile part 2 is referred to as the downlink or forward link connection, while a connection from the mobile part 2 to the base station 1 is referred to as the uplink connection, or reverse link connection. For power control in the downlink, the respective received signal is evaluated in the mobile station 2, and power

control information is produced as a function of this and is sent back to the base station 1, so that the base station 1 can adjust the transmission power appropriately. In order to control the

uplink, the received signal is evaluated in the base station 1, where the power control information is produced and the mobile station 2 is instructed to carry out power matching.

The power control information is in this case transmitted within a predetermined frame structure, depending on the respective mobile radio system.

Figure 3 shows an example of the frame and timeslot structure for a downlink connection in a mobile radio system operated using a code division multiple access method (CDMA). The frame and timeslot structure shown in Figure 3 corresponds in particular to a UMTS mobile radio channel (Universal Mobile Telecommunications System), which is also referred to as DPCH (Dedicated Physical Channel) in accordance with the current state of UMTS standardization. UMTS is the designation for third-generation mobile radio systems, with the aim of a worldwide, universal mobile radio standard. According to the UMTS mobile radio standard, the WCDMA method (Wideband Code Division Multiple Access) is intended for use as the multiple access method.

The frame structure shown in Figure 3 and with a duration of 720 ms comprises, in particular, 72 frames 3 of identical construction and having a frame duration of 10 ms, with each frame in turn each having 16 timeslots 4, with a timeslot duration of 0.625 ms. Each timeslot 4 comprises information split between a logical control channel (DPCCH, Dedicated Physical Control Channel) and a logical data channel (DPDCH, Dedicated Physical Data Channel). The DPCCH section comprises a pilot bit sequence 5 and TPC information (Transmitter Power Control) 6 and TFI information (Transmitter Format Identifier) 7. The DPDCH section comprises user data bits 8. The structure shown in

Figure 3 can be found, for example, in the document ETSI STC SMG2 UMTS-L1: Tdoc SMG2 UMTS-L1 221/98.

The pilot bit sequence 5 is used for estimating the channel impulse response during a training sequence, and corresponds to a known bit pattern. The receiver can determine or estimate the channel impulse response of the mobile radio channel by comparing the received signal with the known pilot bit sequence.

The TFI information 7 is used for format identification for the respective receiver. The TFI bits are protected, according to the present WCDMA Standard, by means of a specific coding method, and are distributed over an entire frame (time duration 10 ms) by interleaving. If the TFI information 7 in each timeslot comprises, for example, three bits b4...b5 as shown in Figure 3, there are a total of 3*16 = 48 TFI bits per frame, which comprises 16 timeslots, and these bits are coded by means of a bi-orthogonal coding method.

The TPC information 6 represents the command, produced by the receiver and transmitted to the transmitter, to adjust the transmission power. To do this, the received power in the receiver or the signal-to-noise ratio in the received signal is compared with a predetermined reference value, and the value for the power adjustment command is determined as a function of the discrepancy. This means that, if the received power exceeds the reference value, a command is produced to reduce the transmission power, while a command to increase the transmission power is produced if the received power is less than the predetermined reference value. Thus, depending on the comparison result, the receiver transmits a digital or binary adjustment command to the transmitter. In this case, a command to increase the transmission power (power up command) is coded with a 1, while a command to reduce the transmission power (power down command) is coded with a 0. In each case, the adjustment command is transmitted to the transmitter after appropriate modulation. According to

the WCDMA Standard for UMTS mobile radio systems that is currently under discussion,

the transmission is carried out by means of QPSK modulation (Quadrature Phase Shift Keying), by which means the binary 1 or 0 are changed to respective values -1 and +1, followed by the power control signal being spread.

The power control information thus generally comprises only one bit, which indicates whether the transmission power should be increased or reduced at the transmission end. In order to allow this bit to be transmitted with a sufficiently low error probability, the bit is transmitted repeatedly. The TPC information shown in Figure 3 in consequence, for example, comprises three bits b1...b3, which are transmitted successively with identical information contents. However, the power control information may also comprise a different number of bits, for example more bits.

Relatively powerful coding methods which are known per se and by means of which it would be possible to achieve a better error probability are not used since the TPC bits will need to be evaluated immediately in the receiver of the TPC information, in order to allow the transmission power to be readjusted appropriately without delay. According to the prior art, the TPC bits are thus not coded together with other bits or data and can also not be distributed over a relatively long time period, for example over an entire frame, which is referred to as interleaving.

However, there is a requirement for the TPC bits to be transmitted correctly with as high a reliability level as possible in order to avoid the transmitter incorrectly or not reliably receiving the corresponding power adjustment command.

The document ETSI SMG2 L1 Expert Group, Tdos SMG2 UMTS-L1 736/98, Espoo, Finland, December 14-18, 1998, "Soft

TPC Interpretation for Improved Closed Loop Power Control" discusses the reliability of the power adjustment command transmitted to the transmitter, and adjustment in as optimum a manner as possible of the

value of the power adjustment command as a function of the reliability of its reception. In this case, the authors indicate that the value of the power adjustment command should be chosen depending on the function tanh ($\Lambda/2$), where Λ represents the reliability of the power adjustment command in the form of a log-likelihood distribution.

The present invention is based on the object of providing an improved method for controlling the transmission power in a radio system, in particular in a mobile radio system, as well as a corresponding radio system, by which means the reliability of transmission of the power control information can be improved.

According to the invention, this object is achieved by a method having the features of claim 1, and by a corresponding mobile radio system having the features of claim 13. The dependent claims each describe preferred and advantageous embodiments of the present invention.

According to the invention, the power control information transmitted in one timeslot is coded together with further data which is intended to be transmitted in the same timeslot. Both the power control information and this further data or information are preferably transmitted in binary form, so that the power control information (TPC bits) transmitted in one timeslot is not simply transmitted repeatedly, but is coded together with further bits, which are intended to be transmitted within the same timeslot. These further bits may be, for example, the bits in the TFI information (TFI bits) in a WCDMA mobile radio system. However, in principle, other bits, for example data bits, can also be used for coding with the TPC bits, provided they are intended to be, or can be, transmitted in the same timeslot at the TPC bits.

The coding method used for coding the TPC bits can in principle be chosen as required. However, the coding method is advantageously chosen such that the coding process provides added redundancy, which can be utilized during reception of the coded power control information to check the transmitted value of the power control information.

The coding method may, for example, comprise the TPC bits being coded together with the further bits to be coded with them to form a common binary data word, at least some of whose bit values depend not only on the value of the TPC bits but also on the value of the further bits, for example the TFI bits. The bits to be coded with one another can thus, in particular, be linked by means of a logic exclusive-OR operation.

The advantage of the invention is that the added redundancy, which results from the dependency of the coded bits on both the value of the TPC bits and the value of the further bits to be coded with them, allows additional estimated values to be obtained for the power control information to be transmitted, which can then be used to check the received power control information, in order to increase the reliability of transmission of the power control information.

The present invention is preferably used in CDMA mobile radio systems, especially in WCDMA mobile radio systems, such as the UMTS mobile radio system. Furthermore, the invention is preferably used in a mobile radio system in the downlink, that is to say for transmission of the power control information from the base station to the mobile station, since CDMA mobile radio systems have increased delay times in the uplink, owing to the code division multiplexing method used. In principle, the present invention

can, however, be applied to any type of radio system in which it is intended to transmit power control information embedded in a (frame and) timeslot structure.

The invention will be explained in more detail in the following text with reference to the attached drawing on the basis of use in the downlink of a WCDMA mobile radio system, in particular a UMTS mobile radio system. In this case:

Figure 1 shows the frame and timeslot structure according to the present invention for a downlink connection in a WCDMA mobile radio system to which the present invention is preferably applied,

Figure 2 shows a schematic illustration of a mobile radio system in order to explain the information transmission for power control, and

Figure 3 shows the known frame and timeslot structure for a downlink connection in a WCDMA mobile radio system.

The frame and timeslot structure shown in Figure 1 indicates the principle on which the present invention is based, with the fundamental layout of this structure corresponding to the structure shown in Figure 3, so that reference should also be made to the corresponding explanatory notes relating to Figure 3.

As has already been described initially, in the structure shown in Figure 3, the bits for power control information 6 (referred to as TPC bits in the following text) are transmitted separately from the further information, to be transmitted in the same timeslot, in a timeslot 4. In particular, the power control information normally comprises only one bit value,

which is transmitted a number of times successively, according to Figure 3, for example, three times in the form of the TPC bits

b1...b3. The further control and data bits are separated from the TPC bits b1...b3.

However, according to the invention, this separation is canceled, and the TPC bits b1...b3 are coded together with further bits which are transmitted in the same timeslot 4. These may be, for example, the bits in the format identification information 7 (referred to as TFI bits in the following text). However, other bits, such as bits in the data information 8, can also possibly be used for coding the TPC bits.

In order to explain the principle on which the invention is based, it is assumed by way of example in the following text that the power control information comprises three TPC bits b1...b3, which are intended to be coded, in redundant form, together with three TFI bits b4...b6 of format identification information. The value of the power control information to be transmitted is denoted p, while the value of the format identification information to be transmitted in the same timeslot 4 is denoted t.

With the conventional structure shown in Figure 3, the bits b1...b3 would all be assigned the value p, while the bits b4...b6 would define the value t, separately from this.

According to one preferred exemplary embodiment of the invention, it is now proposed that a coded data word which is common to the power control information and format identification information be generated from the bits b1...b6, at least some of whose bit values are influenced not only by the value p but also by the value t. In particular, the bits b1...b6 in this coded data word can be allocated as follows, in the course of coding:

b1 = b2 = p

b3 = b4 = p XOR t

b5 = b6 = t

The coded data word thus comprises a total number of bits corresponding to the sum of the TPC bits and TFI bits, in which, however, some of the bits in this data word are occupied only with the TPC value p (see the bits b1 and b2), while a further portion of this data word is occupied only by the TFI value t (see the bits b5 and b6). A third section of the data word is, finally, obtained by means of a logic operation, in particular by means of a logic exclusive-OR operation, between the TPC value p and the TFI value t (see the bits b3 and b4). Thus, in comparison to the conventional structure shown in Figure 3, the bits b3...b6 are used differently in the coding method described above.

After the transmission of this code word with the coded bits b1...b6 to the transmitter for appropriate readjustment of the transmission power, the transmitter can use the information contained in the bits b3...b6 to calculate an estimated value p' for the TPC information. To do this, the transmitter uses b5 and b6 to determine an estimated value for t, so that the estimated value p' can be calculated from the bits b3 and b4, on the basis of the estimated value of t, and utilizing the known XOR function.

This estimated value p' thus replaces the estimated value for the power control information obtained from the bit b3 when using the known structure shown in Figure 3. This procedure has the advantage that p' is in each case based on two bits, with this combination making it possible to achieve a transmission capability that is improved by 3 dB.

The calculation of the XOR function admittedly results in a higher bit error rate. However, at least when the channel or transmission conditions are not very bad, this is more than compensated for by the gain. This will be explained briefly below.

If f denotes the probability that a bit will be detected incorrectly, then the probability of incorrect detection is improved approximately to f^2 if this bit is transmitted twice. On the other hand, the probability of incorrect detection resulting from the XOR calculation deteriorates approximately to 2f since, in this case, the XOR calculation produces an incorrect value just by one of the two XOR-linked values or bits having been detected incorrectly. The coding method described above thus gives better results provided the following relationship is satisfied:

$$2f^2 < f$$

or

$$f < 0.5$$

This relationship is satisfied for WCDM transmission methods, so that the invention ensures improved transmission reliability, particularly when used in (W)CDMA mobile radio systems.

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Patent Claims

1. A method for controlling the transmission power in a radio system,
in which a signal which is received by a receiver (1; 2) via a transmission channel of the radio system from a transmitter (2; 1) is evaluated, and power control information (6) is produced as a function of this and is sent, embedded in a timeslot structure (4), to the transmitter (2; 1),
in which the transmission power is set in the transmitter (2; 1) as a function of the power control information (6),
and
in which, in the receiver (1; 2), the power control information (6) in a one timeslot (4) is coded, and is transmitted to the transmitter (2; 1), together with further data to be transmitted in the same timeslot (4),
characterized
in that the coding is carried out in such a manner that the power control information (6) in a timeslot (4) is coded, with the addition of redundancy, together with further data to be transmitted in the same timeslot (4) to form a common data word, with at least one bit value in the data word depending on the power control information and on the further data.

2. The method as claimed in claim 1,
characterized
in that the further data together with which the power control information (6) is coded is data for format identification information (7).

3. The method as claimed in claim 1,
characterized

in that the further data together with which the power

control information (6) is coded is user data (8).

4. The method as claimed in one of the preceding claims,

characterized
in that the power control information is transmitted in binary form.

5. The method as claimed in claim 4, characterized in that the bits in the power control information (6) are coded with the bits of the further data to form a common binary data word (b1...b6).

6. The method as claimed in claim 5, characterized in that the coded data word comprises a number of bits (b1...b6) corresponding to the sum of the bits in the power control information (6) and the bits in the further data.

7. The method as claimed in claim 5 or 6, characterized in that, during the coding process, at least one bit (b1, b2) in the coded data word is assigned the value of the power control information (6) to be transmitted in the corresponding timeslot (4).

8. The method as claimed in one of claims 5-7, characterized in that, during the coding process, at least one bit (b5, b6) in the coded data word is assigned the value of the information (7) to be transmitted in the corresponding timeslot (4) from the further data.

9. The method as claimed in one of claims 5-8, characterized in that, during the coding process, at least one bit (b4) in the coded data word is assigned the value which corresponds to a logic operation between the power control information (6) to be transmitted in the

corresponding timeslot (4) and the information (7) to be transmitted in the same timeslot (4) from the further data.

10. The method as claimed in claim 9, characterized in that a logic exclusive-OR operation is used as the logic operation.

11. The method as claimed in claim 9 or 10, characterized in that the power control information (6) is recovered in the transmitter (2; 1) by means of appropriate decoding, with an estimated value being determined for the power control information during the decoding process on the basis of the value obtained by the logic operation from the corresponding bit in the coded data word.

12. The method as claimed in one of the preceding claims, characterized in that the receiver (1) which produces the coded power control information (6) is a base station in a mobile radio system, and the transmitter (2) which receives the power control information and sets its transmission level appropriately is a mobile station in the mobile radio system, so that the coded power control information (6) is transmitted via a downlink connection between the receiver (1) and the transmitter (2).

13. A radio system having a transmitter (2; 1), and having a receiver (1; 2) for receiving a signal, which is transmitted via a transmission channel of the mobile radio system, from the transmitter (2; 1) and for evaluating the received signal, in order to produce power control information (6) which is dependent on it and to send this information, embedded in a timeslot structure (4), to the transmitter (2; 1),

in which the transmitter (2; 1) is configured such that it sets the transmission power as a function of the power control information from the receiver (1; 2),

in which the receiver (1; 2) is configured in such a manner that it codes the power control information (6) for a timeslot (4), and transmits it to the transmitter (2; 1), together with further data to be transmitted in the same timeslot (4),
characterized
in that the receiver (1; 2) is configured such that it codes the power control information (6) in a timeslot (4), with the addition of redundancy, together with further data to be transmitted in the same timeslot (4) to form a common data word, with at least one bit value in the data word depending on the power control information and on the further data.

14. The radio system as claimed in claim 13,
characterized
in that the receiver (1; 2) is configured in such a manner that it codes the power control information (6) together with data from format identification information (7) for the same timeslot (4).

15. The radio system as claimed in claim 13,
characterized
in that the receiver (1; 2) is configured such that it codes the power control information (6) together with user data (7) for the same timeslot (4).

16. The radio system as claimed in one of claims 13-15,
characterized
in that the receiver (1; 2) is configured such that it sends the power control information (6) to the transmitter (2; 1) in binary form.

17. The radio system as claimed in claim 16,
characterized

in that the receiver (1; 2) is configured such that it codes the bits in the power control information (6)

together with the bits in the further data to form a common binary data word (b1...b6).

18. The radio system as claimed in claim 17, characterized
in that the receiver (1; 2) is configured such that, during the coding process, it assigns at least one bit (b1, b2) in the coded common data word the value of the power control information (6) to be transmitted in the corresponding timeslot (4).

19. The radio system as claimed in claim 17 or 18, characterized
in that the receiver (1; 2) is configured such that, during the coding process, it assigns at least one bit (b5, b6) in the coded common data word the value of the information (7)
to be transmitted in the corresponding timeslot (4) from the further data.

20. The radio system as claimed in one of claims 17-19,
characterized
in that the receiver (1; 2) is configured such that, during the coding process, it assigns at least one bit (b4) in the coded common data word a value which corresponds to a logic operation between the power control information (6) to be transmitted in the corresponding timeslot (4) and the information (7) to be transmitted in the same timeslot (4) from the further data.

21. The radio system as claimed in claim 20, characterized
in that the logic operation carried out by the receiver (1; 2) during the coding process is a logic exclusive-OR operation.

22. The radio system as claimed in claim 20 or 21, characterized

in that the transmitter (2; 1) is configured such that, after receiving the coded common data word, it recovers the power control information (6) by means of appropriate decoding and, in the process, determines an estimated value for the power control information on the basis of the value obtained by the logic operation from the corresponding bit in the coded common data word.

23. The radio system as claimed in one of claims 13-22,
characterized
in that the radio system is a CDMA mobile radio system.

24. The radio system as claimed in claim 23,
characterized
in that the receiver (1) which produces the coded binary power control information (6) is a base station in the mobile radio system, and the transmitter (2) which receives the power control information and sets its transmission power appropriately is a mobile station in the mobile radio system.

BOX PCT

IN THE UNITED STATES ELECTED/DESIGNATED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

SUBMISSION OF DRAWINGS

APPLICANTS: Bernhard Raaf	DOCKET NO: 112740-344
SERIAL NO:	GROUP ART UNIT:
	EXAMINER:
INTERNATIONAL APPLICATION NO:	PCT/DE00/01021
INTERNATIONAL FILING DATE:	03 April 2000
INVENTION:	METHOD FOR CONTROLLING TRANSMISSION POWER IN A RADIO SYSTEM, AND A CORRESPONDING RADIO SYSTEM

Assistant Commissioner for Patents,
Washington, D.C. 20231

Sir:

Applicants herewith submit two sheets (Figs. 1-3) of drawings for the above-referenced PCT application.

Respectfully submitted,

(Reg. No. 39,056)

William E. Vaughan
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Attorneys for Applicants

FIG 1

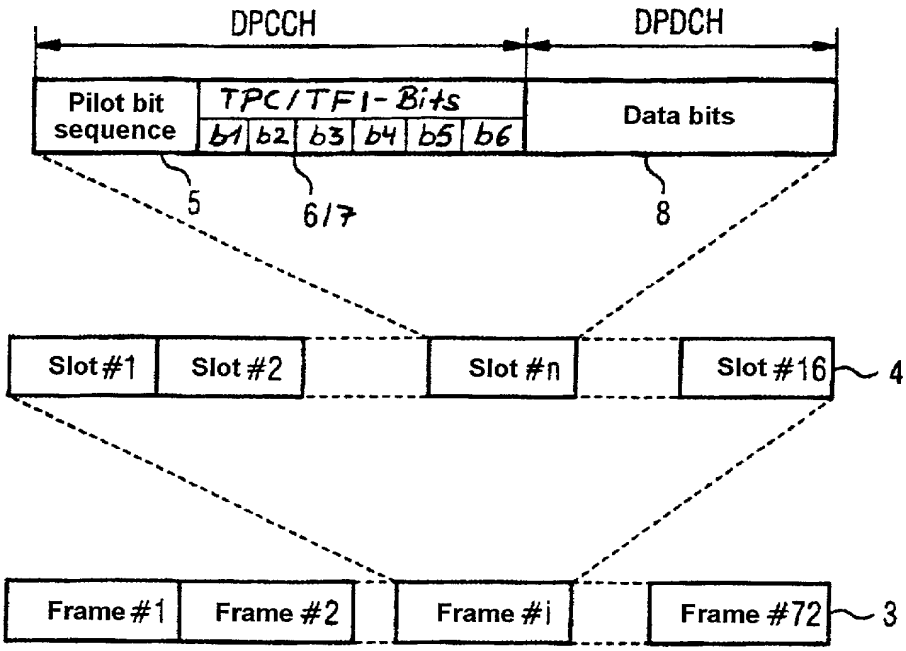

DPCCH
DPDCH
Pilot bit sequence
TPC/TFI-Bits
b1 b2 b3 b4 b5 b6
Data bits
5
6/7
8
Slot #1
Slot #2
Slot #n
Slot #16
4
Frame #1
Frame #2
Frame #i
Frame #72
3

FIG 2

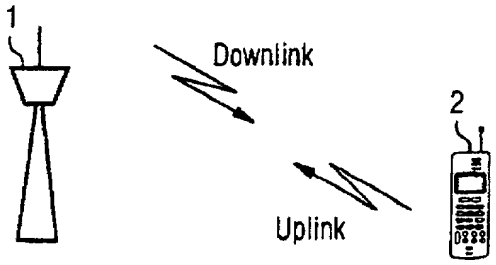
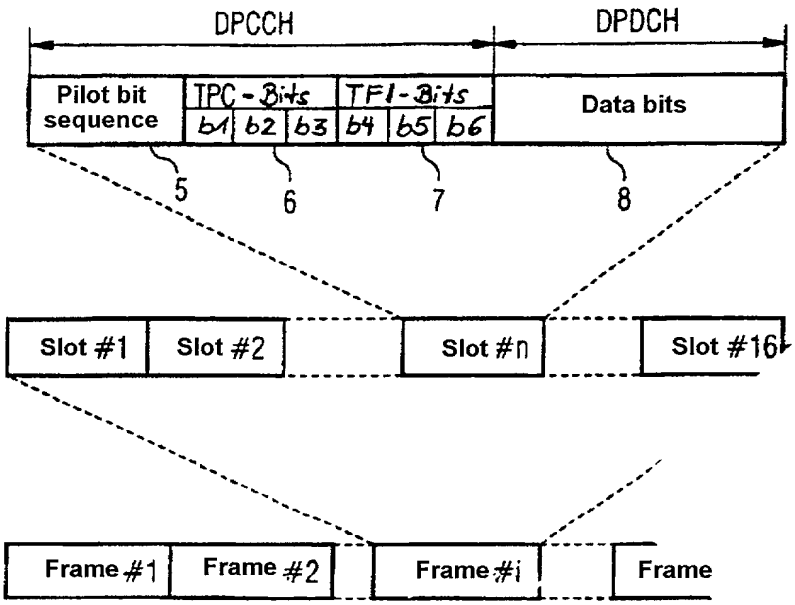


FIG 3 (PRIOR ART)



Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren zur Regelung der Sendeleistung in einem Funksystem und entsprechendes Funksystem

Method for regulating the transmitter power in a radio system and corresponding radio system

deren Beschreibung

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 03.04.2000 als
PCT internationale Anmeldung
PCT Anmeldungsnummer PCT/DE00/01021
eingereicht wurde und am _____
abgeändert wurde (falls tatsächlich abgeändert).

the specification of which

(check one)
☐ is attached hereto.
☒ was filed on 03.04.2000 as
PCT international application
PCT Application No. PCT/DE00/01021
and was amended on _____
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Customer No. 29177

29177 And I hereby appoint

PATENT & TRADEMARK OFFICE

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Ext. _____

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Three First National Plaza, 70 West Madison Street, Suite 3300 60602-4207 Chicago, Illinois
Telephone: (001) 312 372 11 21 and Facsimile (001) 312 372 20 98
or
Customer No. 29177

Voller Name des einzigen oder ursprünglichen Erfinders:	Full name of sole or first inventor:
BERNHARD RAAF	BERNHARD RAAF
Unterschrift des Erfinders / Datum: Bernhard Raaf 8.10.07	Inventor's signature / Date
Wohnsitz: MUENCHEN, DEUTSCHLAND DEX	Residence: MUENCHEN, GERMANY
Staatsangehörigkeit: DE	Citizenship: DE
Postanschrift: MAXHOFSTR. 62 81475 MUENCHEN	Post Office Addess: MAXHOFSTR. 62 81475 MUENCHEN
Voller Name des zweiten Miterfinders (falls zutreffend):	Full name of second joint inventor, if any:
Unterschrift des Erfinders / Datum	Second Inventor's signature / Date
Wohnsitz	Residence
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).

German Language Declaration

Prior foreign appplications Priorität beansprucht			Priority Claimed	
19918372.4 (Number) (Nummer)	DE (Country) (Land)	22.04.1999 (Day Month Year Filed) (Tag Monat Jahr eingereicht)	☒ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

PCT/DE00/01021 (Application Serial No.) (Anmeldeseriennummer)	03.04.2000 (Filing Date D, M, Y) (Anmeldedatum T, M, J)	anhängig (Status) (patentiert, anhängig, aufgegeben)	pending (Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

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